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REMARKS**Rejection of Claims 1-96 as Originally Filed**

In the June 29, 2006 Office Action, all claims 1-96 then pending in the application were rejected. Specifically,

- ☐ claims 1-16, 20-43 and 47-64 were rejected under 35 USC 102(b) as anticipated by Wade et. al. (US 6,440,495);
- ☐ claims 65-84 and 88-96 were rejected under 35 USC 102(b) as anticipated by Jin et. al. (US 6,479,100);
- ☐ claims 17-19 and 44-46 were rejected under USC 103(a) as being unpatentable over Wade et. al. in view of Aaltonen et. al. (US 2003/0165615); and
- ☐ claims 85-87 were rejected under USC 103(a) as being unpatentable over Jin et. al. in view of Aaltonen et. al. (US 2003/0165615).

By this response, claims 1-3,5-8, 11-13, 20, 21, 27, 30, 31, 37-39, 41, 43, 45-47, 54, 56-59, 63-65, 68-71, 74-78, 80-82, 88, and 89 have been amended; claims 9, 10, 15, 24-26, 32-36, 42,44, 79, and 94-96 have been cancelled; and new claims 97-112 have been added.

No new matter (35 USC 132) has been added by any of the amendments and the claims, as now presented, are patentable over the art.

Claim Amendments/New Claims

In light of the number of amended claims and the degree to which many of the claims have been amended; rather than discuss the support for each amendment, the undersigned has presented an appendix to this response, Appendix A. This appendix sets forth the more significantly amended claims and identifies the paragraph(s) of the specification where support for the amendments is found. Please note that because the paragraph numbering between the application as filed and as published is different, the designation in Appendix A is to the paragraph numbers as published in US2005/0186341.

Most of the amendments to the claims are merely editorial in nature, e.g., altering the claim dependency, correcting obvious errors/omissions, or consolidating claims for improved clarity and simplicity. With respect to the latter, for example, rather than present two complete sets of claims as to the identity of the suitable precursors and their form, the claims now merge the relevant claims to indicate that both

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precursors are independently selected from the groups specified. Generally speaking, all of these type amendments are self-explanatory and no further discussion will be set forth.

In addition to the aforementioned claims, Applicants have made certain substantive amendments to the independent claims to more clearly and succinctly define the appertaining subject matter. For example, claim 1 has been amended to clarify that both the seed layer and the upper layer are ruthenium metal and to specify those conditions which are critical to establishing such metal layers.

Similarly, independent claim 65 has been amended to add clarity to the process steps identified as well as incorporate those parameters which are particularly pertinent to the claimed method.

Finally, new independent claim 97 embraces the embodiment of the present invention wherein two different ruthenium sources are employed. The revised and newly presented dependent claims merely set forth with additional specificity and clarity particular preferred embodiments of each independently claimed method. No new matter has been presented by way of any of the amendments or newly added claims, since all amendments and new claim limitations are specifically supported by the specification as filed.

Applicants submit that the claims as presented embody patentable subject matter. Applicants therefore request swift and early allowance.

Rejections of Claims and Traversal Thereof

Anticipation by Wade et. al.

In the June 29, 2006 Office Action, claims 1-16, 20-43 and 47-64 were rejected under 35 USC 102(b) as anticipated by Wade et. al. (US 6,440,495). The Office alleges that Wade et. al. teach a method of forming a ruthenium film on a titanium nitride by CVD (column 4, line 59 – column 5, line 13) using a ruthenium oxide seed layer deposited by CVD prior to deposition of the bulk layer (column 5, line 14-37). It is stated that the examples and tables anticipate all the process conditions claimed by applicant. Applicants respectfully traverse the rejection and request reconsideration.

It is well established, as a matter of law, that a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Bros. v. Union Oil Co. of California*, 2 U.S.P.Q.2d 1051, 1053 (Fed. Cir. 1987). Anticipation is not found here.

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Wade et. al. teach a method of forming ruthenium films by CVD in the kinetically limited temperature regime. Though an objective of Wade et. al. is to avoid the need for a ruthenium seed layer (see Table 1, Column 7, line 18), Wade et. al. repeatedly teach of the importance and benefits of the use of a PVD (physical vapor deposition) seed layer. For example, at column 10, lines 42-45, Wade et. al. state "The lower activation energies and higher deposition rates on PVD Ru highlight the importance of using a PVD Ru seed layer as a substrate for CVD Ru growth." At column 14, lines 44-45, Wade et. al. state "Using the same process conditions, the surface morphology was improved by using a thin PVD Ru seed layer....". At column 16, lines 12-13, Wade et. al. state "By depositing CVD Ru onto a PVD Ru seed layer, the film roughness and step coverage can be greatly reduced." Although CVD of a ruthenium oxide seed layer is suggested, there is no teaching whatsoever as to how to produce such a seed layer. Besides, the foregoing certainly makes clear that PVD deposition of the ruthenium seed layer is paramount. Perhaps the most telling of indicators as to the state of the art relating to ruthenium seed layer formation, is the statement in Table 1 (column 7, line 18) of Wade et. al. that the "Current Best Known Method" for Ru CVD film formation "requires PVD seed layer."

The foregoing contrasts sharply with applicants' invention as presented in independent claim 1, wherein a ruthenium metal seed layer is formed by CVD, and not a ruthenium oxide seed layer as suggested by the Patent Office, nor a ruthenium seed layer formed by PVD as specifically shown in Wade et. al. Specifically, Applicants have found that certain CVD conditions allow for the formation of a ruthenium metal seed layer, such conditions including a ruthenium precursor/co-reactant gas mixture comprising at least 30 mole % of a co-reactant gas, deposition temperatures of from 250°C to 340°C and a precursor flow rate that, under the deposition conditions, provides for a surface reaction-rate limited deposition. None of these conditions are suggested, shown or specified in Wade et. al. nor, more importantly, is there any suggestion, motivation or inference as to the possibility of the **CVD deposition of a ruthenium metal seed layer**. Thus, Wade et. al. do not anticipate claim 1 or any of its dependent claims.

Inasmuch as Wade et. al. do not specifically teach or suggest the process or conditions of Applicants' method, the anticipation rejection of Claims 1-16, 20-43 and 47-64 fails and amended independent claim 1 and all claims dependent thereof, as now presented, are patentably delineated over Wade et. al. Applicants respectfully request that the rejection be withdrawn and that claims 1-8, 11-14, 16-23, 27-31, 37-41, 43, and 45-64 be passed to allowance.

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Anticipation by Jin et. al.

In the June 29, 2006 Office Action, claims 65-84 and 88-96 were rejected under 35 USC 102(b) as anticipated by Jin et. al. (US 6,479,100). It is alleged that Jin et. al. (column 4, lines 14-44) teach a method of forming a ruthenium film on a titanium nitride by depositing a ruthenium oxide seed layer followed by an annealing step that removes the oxygen content from the film layer and wherein the process is repeated to deposit subsequent layers (column 4, lines 14-44). Further, the examples are said to anticipate all the process conditions claimed by the Applicants. Applicants respectfully traverse the rejection and request reconsideration.

As set forth above, it is well established, as a matter of law, that a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Bros. v. Union Oil Co. of California*, 2 U.S.P.Q.2d 1051, 1053 (Fed. Cir. 1987). Anticipation is not found here.

In contrast to the allegation of the Patent Office, the cited text of Jin et. al. teaches the formation of a ruthenium oxide seed layer by CVD of a ruthenium precursor under oxygen rich conditions to form a ruthenium oxide (RuO_2) layer which is then annealed for form a reduced ruthenium oxide layer denoted by the formula RuO_y wherein y is less than 2. **No mention whatsoever is made of repeating the process steps to form a ruthenium thin film**, nor would such be suggested as that would merely result in the production of a ruthenium oxide film not a ruthenium metal film as required. Indeed, as taught by Jin et. al. at column 5, lines 38-47, a ruthenium metal film is subsequently deposited on the reduced ruthenium oxide seed layer by MOCVD of certain precursors.

In contrast, the process of Applicants' independent claim 65, from which the remaining rejected claims depend, requires that the ruthenium metal film be formed by a repeated process of depositing a ruthenium seed layer, deoxygenating the seed layer, depositing another seed layer, deoxygenating that subsequent seed layer, etc. **Except for the duration of the seed layer deposition step, the material and deposition conditions do not substantially change from one cycle to the next.** Jin et. al., on the other hand, clearly use materials and conditions in the seed layer formation that are different from those used in the subsequent film forming process.

Inasmuch as Jin et. al. do not specifically teach or suggest the process or conditions of Applicants' method, the anticipation rejection of Claims 65-84 and 88-96 fails and amended independent claim 65, and all those claims dependent thereon, as now presented, are patentable over Jin et. al. Applicants

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respectfully request that the rejection be withdrawn and that claims 65-78 and 80-93 be passed to allowance.

Obviousness over Wade et. al. in view of Aaltonen et. al.

In the June 29, 2006 Office Action, claims 17-19 and 44-46 were rejected under 35 USC 103(a) as being unpatentable over Wade et. al. (US 6,440,495) in view of Aaltonen et. al. (US 2003/0165615). It is alleged that Wade et. al. teaches all of the limitations of Applicants invention and claims except for specifically teaching the use of Ru(thd)₃ as the ruthenium precursor. Aaltonen et. al. are said to teach the art recognized suitability of using Ru(thd)₃ as the ruthenium precursor. The Patent Office contends that it would have been obvious to one of ordinary skill in the art to use Ru(thd)₃ as the ruthenium precursor in Wade et. al. and, in doing so, have a reasonable expectation of success. Applicants respectfully traverse the rejection and request reconsideration.

As noted above, Wade et. al. do not teach, nor do they make obvious, Applicants' method of forming a ruthenium metal film on a substrate wherein the ruthenium metal film comprises a ruthenium metal seed layer and a upper ruthenium metal film layer, wherein both layers are formed by CVD under two different sets of conditions, the first being certain conditions that favor formation of ruthenium metal film that is suitable for and acts as a seed layer and the second being conditions that form a more traditional-like ruthenium metal film of low resistivity. Wade only exemplifies and provides specific teaching for ruthenium PVD seed layers. And, while the Patent Office further attributes the formation of ruthenium oxide seed layers to Wade et. al., nowhere is there any suggestion, teaching or motivation whatsoever as to the preparation of a **ruthenium metal seed layer by CVD**. Aaltonen et. al. does not help overcome this deficiency (as it is directed to ALD of ruthenium metal films) and, indeed, is not cited for this purpose. Rather, Aaltonen et. al. is cited as motivation for the substitution/selection of Ru(thd)₃ as the ruthenium precursor in the method of Wade et. al. Thus, even if there were a reason or motivation to make the substitution, one still does not arrive at Applicants' invention as claimed.

In light of the foregoing discussion, it is apparent that the Patent Office has failed to establish a case of *prima facie* obviousness. The latter is premised upon a finding of each element of the claimed invention in a plurality of references; yet no such finding is presented here. Thus, what the combination teaches, whether combination of the references is appropriate, and whether that combination would be successful is irrelevant to the patentability of the present invention since the presently claimed invention is neither embraced by nor an obvious variant of the teaching of the primary reference. Merely substituting one ruthenium precursor for another does not lend any guidance to or detract from the uniqueness and

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patentability of the method as claimed. Thus, the obviousness rejection of claims 17-19 and 44-46 should be withdrawn and the claims passed to allowance.

Obviousness over Jin et. al. in view of Aaltonen et. al.

In the June 29, 2006 Office Action, claims 85-87 were rejected under 35 USC 103(a) as being unpatentable over Jin et. al. (US 6,479,100) in view of Aaltonen et. al. (US 2003/0165615). It is alleged that Jin et. al. teach all of the limitations of Applicants' invention and claims but for specifically teaching the use of Ru(thd)₃ as the ruthenium precursor. Aaltonen et. al. are said to teach the art recognized suitability of using Ru(thd)₃ as the ruthenium precursor. The Patent Office contends that it would have been obvious to one of ordinary skill in the art to use Ru(thd)₃ as the ruthenium precursor in Jin et. al. and, in doing so, have a reasonable expectation of success. Applicants respectfully traverse the rejection and request reconsideration.

As noted above, Jin et. al. do not teach, nor do they make obvious, Applicants' method of forming a ruthenium metal film on a substrate by repeatedly performing a two step process of depositing a ruthenium seed layer by CVD followed by deoxygenation in order to build a ruthenium metal film. Here, but for the duration of the seed layer deposition step, the materials and conditions of each cycle are substantially the same. Specifically, here one forms a ruthenium seed layer by CVD, deoxygenates that seed layer, deposits another CVD seed layer on the now deoxygenated seed layer, deoxygenates that seed layer and repeats that process for so long as needed to generate the desired ruthenium film. Aaltonen et. al. does not help overcome this deficiency (as it is directed to ALD of ruthenium metal films) and, indeed, is not cited for this purpose. Rather Aaltonen et. al. is cited as motivation for the substitution/selection of Ru(thd)₃ as the ruthenium precursor in the method of Jin et. al. Thus, even if there were a reason or motivation to make the substitution, one still does not arrive at Applicants' invention as claimed.

In light of the foregoing discussion, it is apparent that the Patent Office has failed to establish a case of *prima facie* obviousness. The latter is premised upon a finding of each element of the claimed invention in a plurality of references; yet no such finding is presented here. Thus, what the combination teaches, whether combination of the references is appropriate, and whether that combination would be successful is irrelevant to the patentability of the present invention since the presently claimed invention is neither embraced by nor an obvious variant of the teaching of the primary reference. Merely substituting one ruthenium precursor for another does not lend any guidance to or detract from the uniqueness and

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patentability of the method as claimed. Thus, the obviousness rejection of claims 85-87 should be withdrawn and the claims passed to allowance.

Fees Payable

No claims fees are due or payable as a result of the foregoing amendment. Applicants have previously paid for 3 independent claims and 95 total claims (the original claim numbering was in error, a claim 15 was never presented, and a credit subsequently issued to the undersigned's Deposit Account). By this response, even with the number of new claims, the number of independent claims is 3 and the total number of claims is still 95. Nevertheless, authorization is hereby given to charge any deficiency in applicable fees for this response to Deposit Account No. 08-3284 of Intellectual Property/Technology Law.

CONCLUSION

Applicants have satisfied all requirements for patentability. The now pending claims are free of the art and fully comply with the requirements of 35 U.S.C. §102 and §103. Therefore, it is hereby requested that Examiner Fuller reconsider the patentability of the pending claims in light of the clarifying amendments and distinguishing remarks herein, and withdraw the rejections made in the June 29, 2006 Office Action, thereby placing the application in condition for allowance. A Notice of Allowance is merited and respectfully requested. In the event that any issues remain, Examiner Fuller is requested to contact the undersigned attorney at (919) 419-9350 to resolve same, so that this application can be passed to issue at an early date.

Respectfully submitted,



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APPENDIX A

Support for claims changes in amended claims (parenthetically identified).

1. (Currently Amended) A method for depositing a ruthenium thin film onto a substrate, said method comprising:

(a) depositing a nucleation layer comprising ruthenium metal (*Example 2*) onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited using a nucleation layer first ruthenium precursor/co-reactant gas mixture having greater than about 30 mole percent of the co-reactant gas (*Paragraph 0055*), under nucleation layer CVD conditions, including a temperature of from about 250°C to about 340°C (*Paragraph 0053*) and a ruthenium precursor gas flow rate that is sufficient to maintain a surface reaction rate-limited deposition (*Paragraph 0056*); and

(b) depositing an upper layer comprising ruthenium metal onto the nucleation layer by chemical vapor deposition, wherein the upper layer is deposited using a second ruthenium precursor/co-reactant gas an upper layer mixture having less than 50 mole percent of the co-reactant gas (*Paragraph 0064*) under upper layer CVD conditions, including a ruthenium precursor gas flow rate that is less than that needed to maintain a surface reaction rate-limited deposition (*Paragraph 0065*).

2. (Currently Amended) The method of claim 1, wherein the upper layer CVD conditions are more reducing than the nucleation layer CVD conditions (*Paragraph 0061*) comprises ~~ruthenium oxide~~.

3. (Currently Amended) The method of claim 1, wherein the ruthenium precursor gas flow rate for the nucleation layer is in the range of from about 2 µmol/min to about 100 µmol/min (*Paragraph 0056*) nucleation layer CVD conditions comprise temperature in a range of about 250°C and about 340°C.

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30. (Currently Amended) The method of claim ~~[[29]]~~ 1, wherein the upper layer CVD conditions comprise pressure in a range of about ~~[[0.4]]~~ 0.2 Torr to about 1.0 Torr. (Paragraph 0063)
46. (Currently Amended) The method of claim ~~[[41]]~~ 43, wherein the first ruthenium precursor is a ruthenium β -diketonate and the second ruthenium precursor is a ruthenocene comprises $\text{Ru}(\text{thd})_3$ or $\text{Ru}(\text{hfac})_3$. (Paragraph 0070)
58. (Currently Amended) The method of claim 1, wherein from about 80 mole% to about 90 mole% of the first ruthenium precursor/co-reactant gas mixture is oxygen (Paragraph 0054 and Table 4) further comprising annealing the ruthenium thin film following deposition of the upper layer on the nucleation layer.
59. (Currently Amended) The method of claim ~~[[31]]~~ 1, wherein from about 80 mole % to about 95 mole % of the first ruthenium precursor/co-reactant gas mixture is oxygen and from about 1 mole % to about 10 mole % of the second ruthenium precursor/co-reactant gas mixture is oxygen precursor is different than the first ruthenium precursor. (Paragraphs 0055 and claim 37)
64. (Currently Amended) The method of claim 1, wherein each co-reactant gas is individually selected from the group consisting of oxygen, hydrogen, steam, nitrous oxide, ozone, carbon monoxide, carbon dioxide, and mixtures of oxygen and hydrogen the ruthenium thin film comprises the nucleation layer and the upper layer. (Paragraph 0049)
65. (Currently Amended) A method for depositing a ruthenium thin film onto a substrate, said method comprising:
- (a) depositing a nucleation layer comprising ruthenium onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited from a nucleation layer ruthenium precursor/co-reactant gas mixture comprising at least 30 mole % of a co-reactant gas (Paragraph 00553) in an oxidizing environment under nucleation layer CVD conditions; and
 - (b) deoxygenating the so formed nucleation layer ~~comprising ruthenium~~ in a reducing environment, in the absence of the ruthenium precursor/co-reactant gas mixture (Paragraph 0069) ; and

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~~wherein (a) and (b) are repeated sequentially and continuously (c) sequentially repeating steps (a) and (b) until the ruthenium thin film of desired thickness is deposited onto the substrate.~~

68. (Currently Amended) The method of claim 65, wherein the deoxygenating step is conducted under conditions comprising pressure in a range of about 0.1 Torr to about 100 Torr and a temperature in a range of about 250°C to about 350°C. *(Original claim 69)*

75. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the deoxygenation is accomplished by annealing first ruthenium precursor comprises a solid. *(Paragraph 0068 and 0069, inherent)*

76. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the ~~first flow rate of the ruthenium precursor is sufficient to maintain surface reaction rate-limited deposition comprises a liquid.~~ *(Paragraph 0056)*

77. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the CVD conditions include a pressure of from about 0.1 Torr to about 5.0 Torr, a temperature of from about 250°C and about 340°C, and a flow rate of the first ruthenium precursor of from about 15 µmol/min to about 30 µmol/min and the co-reactant gas is oxygen and is present in a concentration of from about 80 mole % to about 95 mole % is dissolved in a solvent to form a first ruthenium precursor solution. *(Paragraphs 0053- 0056)*

78. (Currently Amended) The method of claim 77, wherein the co-reactant gas is present in a concentration of from about 80 mole % to about 90 mole % solvent comprises a reducing solvent. *(Paragraph 0054 and Table 4)*

97. (New) A method for depositing a ruthenium thin film onto a substrate, said method comprising:

(a) depositing a nucleation layer comprising ruthenium onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited using a nucleation layer mixture containing a first ruthenium precursor under nucleation layer CVD conditions; and

(b) depositing an upper layer comprising ruthenium onto the nucleation layer by chemical vapor deposition, wherein the upper layer is deposited using an upper layer mixture containing a

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second ruthenium precursor, different from the first, under upper layer CVD conditions.

(Paragraph 0070)

98. (New) The method of claim 97, wherein the first and second ruthenium precursors are selected from the group consisting of ruthenocenes, ruthenium β -diketonates, fluorinated ruthenium β -diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides.

(Paragraphs 0035- 0049 and 70)

107. (New) The method of claim 97, wherein the nucleation layer CVD conditions include a temperature of from about 250°C to about 340°C and a flow rate of the first ruthenium precursor of from about 15 $\mu\text{mol/min}$ to about 30 $\mu\text{mol/min}$ and the co-reactant gas is oxygen and is present in a concentration of from about 80 mole % to about 95 mole % and the upper layer CVD conditions include a temperature of from about 250°C to and about 400°C and a flow rate of the second ruthenium precursor of from about 5 $\mu\text{mol/min}$ to about 20 $\mu\text{mol/min}$ and from about 1 mole % to about 10 mole % of the second ruthenium precursor/co-reactant gas mixture comprises oxygen. **(Paragraphs 0053- 0065).**

110. (New) The method of claim 97 wherein the flow of the first ruthenium precursor is sufficient to maintain a surface reaction rate-limited deposition and the flow of the second ruthenium precursor is less than that needed to maintain a surface reaction rate-limited deposition. **(Paragraphs 0056 and 0065)**

111. (New) The method of claim 110, wherein the nucleation layer CVD conditions include a temperature of from about 250°C to about 340°C and the first co-reactant gas comprises more than 30mole % of the first ruthenium precursor/co-reactant gas mixture. **(Paragraphs 0053- 0055)**

112. (New) The method of claim 97, wherein the upper layer CVD conditions are more reducing than the nucleation layer CVD conditions. **(Paragraph 0061)**